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Short-term Effects of Initial Flood Disturbance on Restoration Projects: Waterbirds and Wetland Vegetation

Final Report

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Introduction

The resilience of floodplain restorations to stochastic disturbance events must be better understood to maximize conservation delivery in highly-altered river systems (Tockner and Standford 2001, Ward et al. 2001). Case studies are needed to further our understanding of the effects of major flooding within areas where river restoration activities have been conducted (Palmer et al. 2005). While the benefits of floodplain connectivity are recognized (Opperman et al. 2010), the consequences of reconnecting highly-modified rivers with floodplains are becoming apparent and a universal approach to floodplain restoration may be ill-advised (Jackson and Pringle 2010, Kreiling et al. 2013).

While timely flood pulses into floodplains and backwater lakes can increase species richness, species diversity, growth of some aquatic macrophytes, and overall productivity (Bayley 1995, Sparks 1995, Robertson et al. 2001), unregulated flooding can lead to increased nutrient discharge (Kreiling et al. 2013), colonization by invasive species, changes in invertebrate and zooplankton communities (Galat et al. 1998), and other undesirable effects (Jackson and Pringle 2010). Due to unpredictable and variable timing of floods, unregulated connectivity to rivers with highly-altered water regimes can encourage invasive species, suppress growth of aquatic macrophytes, and limit recruitment of woody vegetation (Sparks 1995, Galat et al. 1998, Robertson et al. 2001, Tockner and Stanford 2002).

Due to potential deleterious effects of unregulated flooding, some large-river floodplain restoration activities incorporate partial, limited, or managed connections between rivers and their former floodplains. Limited connections often occur between floodplains formerly occupied by agricultural activities with large levees still in place (e.g., drainage and levee districts; Bellrose et al. 1983). Thus, habitats of wildlife and ecosystem components (e.g., wetlands) are restored or created within former floodplains resulting in alternative ecosystems, but the floodplains are not allowed to have an unregulated hydrologic connection with the adjacent river due to altered conditions which would likely preclude existence of high-quality wildlife habitat (Jackson and Pringle 2010). Restoration of wetlands, lakes, and other floodplain-associated environments with limited connections may prevent summer flooding or movements of undesirable species into restored areas. However, catastrophic floods and failure of infrastructure may expose restored areas to unregulated connectivity with large rivers and the resiliency of restored areas has not been previous explored.

During spring 2013, record flooding occurred on the Illinois River. Emiquon and Merwin Preserves, two restored but hydrologically-isolated floodplains, were reconnected to the Illinois River for the first time in >80 years. Both Preserves are owned and managed by The Nature Conservancy and have been the focus of monitoring efforts since restoration began. Moreover, flooding intensity was not equal at these locations. Levees at Merwin Preserve breached, establishing a two-way hydrologic connection between the floodplain and the Illinois River at moderate river stages (i.e., partial connection). Conversely, levees held at Emiquon Preserve, facilitating a one-way input of water into this floodplain over top of levees (i.e., limited connection). These conditions created two case studies under which a natural experiment unfolded.

Our objective was to document and assess site-specific post-flood changes in biotic communities from pre-flood states and trajectories. We hypothesized that waterbird communities would remain unchanged at Emiquon Preserve, but these communities would be negatively affected by the partial river connection at Merwin Preserve. Consequently, we anticipated less overall waterbird use, lower species diversity, and a shift in dominant species from herbivorous and granivorous waterbirds to piscivorous birds at Merwin Preserve. Likewise, we hypothesized that vegetation communities would be negatively affected by the partial river connection at Merwin Preserve resulting in decreased submersed and emergent aquatic macrophyte coverage, but vegetation communities would remain resilient to the limited connection at Emiquon Preserve and change minimally.

Methods

Merwin Preserve (484 ha) and Emiquon Preserve (2,723 ha) are former drainage and levee districts which were cleared, drained, and enclosed by levees in the 1920s and subsequently farmed for approximately 80 years until secured by The Nature Conservancy. Drainage infrastructure was dismantled at Merwin (1999) and Emiquon Preserves (2006) and water was allowed to naturally accumulate behind the river levees creating wetlands and associated habitats for wildlife and fishes. Both preserves remained isolated from the Illinois River until April 2013, when flood water overtopped their levees. In order to evaluate the short-term response of Emiquon and Merwin Preserves to different levels of river connection, we mapped aquatic vegetation communities and other cover types during autumns 2007–2013 and monitored waterbird communities during autumn migration (i.e., October–January) 2008–2013 and spring migration (i.e., March–April) 2008–2014.

In autumn 2013 at Merwin Preserve, we conducted transect surveys from the ground or boats at 500-m intervals, classified vegetation and other cover types encountered along transects (Cowardin et al. 1979), and documented cover transitions using an Archer field computer (Juniper Systems, Inc.) and ArcPad software. Following field documentation, we digitized boundaries of vegetation communities using ArcMap 10.1 layered on color-infrared aerial imagery obtained during September 2013 by the U.S. Fish and Wildlife Service. Following 2013 classification, we used available aerial imagery at Merwin Preserve (e.g., USDA National Agricultural Imaging Program) and ancillary observations and data, photographs, and experience of field personnel to classify cover types during autumns 2007–2012, prior to initiation of this project. Similarly, we digitized cover types at Emiquon Preserve during 2008–2013 using ground surveys and annually-obtained aerial photographs. We did not include results from Emiquon mapping in 2007 due to limited surface water coverage. Cover mapping at Emiquon Preserve was supported through a concurrent agreement between the Illinois Natural History Survey (INHS) and The Nature Conservancy and the data is supplied in-kind for this project.

We identified and enumerated waterfowl and other waterbirds weekly during mid-October – early January 2008–2013 at Emiquon and Merwin Preserves and at 21 other locations in the Illinois River valley (IRV; Fig. 1). We identified and enumerated diving ducks and mergansers weekly during March – April 2012–2014 at Emiquon and Merwin Preserves and at 58 other locations in the Illinois and Central Mississippi River valleys (Fig. 2; all scientific names and guilds included in Table 1). Surveys were conducted by an INHS biologist with >10 years aerial survey experience from a fixed-wing, single-engine aircraft at altitudes of 60–140 m and speeds of 160–240 km/hr (Havera 1999). Aerial surveys were supported by a concurrent agreement between INHS and the Illinois Department of Natural Resources, and the data are provided in-kind for this project. At Emiquon Preserve during 2008–2013, we additionally counted waterbirds during ground-based surveys from mid-February through mid-April to capture spring migration of all waterfowl and other waterbirds. We calculated peak abundances and overall use days by species and guild during each monitoring period (Havera 1999). We calculated use-day density by dividing total use days by area of each survey location.

Results

Emiquon Preserve

The total area of wetland vegetation communities and associated cover types at Emiquon Preserve increased 9.1% from 2012 to 2013 and was 14.9% greater than the 2008–2012 (hereafter, long term) average (Table 2). The aquatic bed plant community (i.e., submersed and floating-leaf aquatic vegetation) increased in size 18.1% from 2012 to 2013 and was 13.6% greater than the long-term average. Hemi-marsh vegetation (i.e., 30%–70% cover of emergent vegetation) increased 53.9% from 2012 but remained 34.5% below the long-term average. Non-persistent emergent vegetation (e.g., moist-soil

vegetation) decreased 46.7% from 2012 and was 30.2% below the long-term average. Open water decreased 7.2% from 2012 and was 10.3% below the long-term average. Although mudflats typically comprise 2.0% of Emiquon Preserve and comprised 5.2% in autumn 2012, no measurable area was mapped in 2013. Finally, persistent emergent vegetation (i.e., dense emergent vegetation with >70% coverage) cover in 2013 was similar to 2012 (-2.3%) and was 98.2% above the long-term average.

Overall, waterfowl and other waterbird use-day densities in autumn 2013 were similar to the long-term average (+0.2%) but 10.5% above autumn 2012 estimates, a drought year which facilitated drawdowns and created abundant foraging habitat for dabbling ducks in other areas of the IRV. Dabbling duck use-day densities decreased by 6.3% from 2012 and were 9.3% below the long-term average. Similarly, non-mallard dabbling duck use-day densities decreased by 3.4% in 2013 from 2012 and were similar to the long-term average (+0.2%). Moreover, we observed a 68.2% decrease in piscivore use-day density from 2012 to 2013, and levels were 37.4% below the long-term average. In contrast, herbivorous species increased 41.8% in 2013, and densities were 15.6% above the long-term average. Granivorous waterbirds decreased by 15.1% from 2012 and use-day densities were 21.2% below the long-term average. Relative to the 23 aerially-surveyed lakes and wetlands in the IRV during autumn 2013, use-day densities at Emiquon Preserve ranked 4th for all waterbirds and diving ducks, 6th for non-mallard dabbling ducks, and 10th for dabbling ducks.

Diving duck use days calculated from aerial surveys conducted during spring 2014 were 16.3% greater than the 2012–2013 (hereafter, long term) average. Relative to 59 other aerially-surveyed lakes and wetlands in the IRV, use-day density at Emiquon Preserve ranked 15th for all diving ducks, 17th for lesser scaup, 9th for canvasback, and 25th for ring-necked duck, all taxa of conservation priority in the region. During spring 2014, total waterfowl and other waterbird use days calculated from ground surveys increased 21.8% from 2013 but were 5.7% less than the long-term average. We observed decreases in use-day densities from 2013 to 2014 for dabbling ducks (-29.7), non-mallard dabbling ducks (-25.7%), piscivores (-41.9%), and granivores (-40.4%) but observed increases in herbivore (117.8%) and diving duck (58.4%). Total waterbird (-5.7%), dabbling duck (-28.2%), diving duck (-16.1%), non-mallard dabbling duck (-31.6%), piscivore (-20.4%), and granivore (-42.1%) use-day densities remained below long-term averages, but herbivore use-day density was 47.7% above the long-term average.

Merwin Preserve

The breached river levee led to a near-complete drawdown in late summer 2013 and abundant non-persistent emergent vegetation at Merwin Preserve (Table 3). However, little surface water during summer limited growth of persistent emergent and aquatic bed vegetation. Coverage of aquatic bed decreased by 100% in 2013, with no measurable aquatic bed plant community present compared to the 2007–2013 (hereafter, long term) average of 14.2%. Mudflat area was 133.1% above the long-term average, but down 40.4% from 2012, a drought year. Non-persistent emergent vegetation was 13% more than the long-term average and 39% greater than 2012. Open water was 24.6% greater than the long-term average but 7.9% less than 2012. Across study years, we noted an increasing trend in the proportion of open water and a decreasing trend in non-persistent emergent vegetation.

In autumn 2012, little to no water was available at Merwin Preserve for autumn-migrating waterbirds due to a drought; thus, annual comparisons were made with 2011 instead of 2012. Total waterfowl and other waterbird use days in 2013 decreased 23.2% and estimates were 39.5% less than the 2007–2011 average (hereafter, long-term average). Virtually no diving ducks used Merwin Preserve during autumn, similar to previous years, and dabbling duck (-89.0%) and non-mallard dabbling duck (-82.7) use-day densities were below 2011 estimates and long-term averages (-90.9% and -87.4%, respectively). Granivore (-88.4%) and herbivore (-99.2%) use-day density decreased from 2011 to 2013

and both were well below the long-term average (-88.9% and -99.8%, respectively). Piscivore use days increased 101.8% from 2011 and were well above the long-term average (98.5%). Relative to all 23 aerially-surveyed lakes and wetlands in the IRV during autumn, use-day density ranked 23rd for all waterbirds, dabbling ducks, and diving ducks, and 21st for dabbling ducks other than mallards.

Diving duck use days during spring at Merwin Preserve were much greater in 2014 than previous years, but low water levels at Merwin Preserve in early spring 2012 and 2013 limited available habitat there and we limited inference to other aerially-surveyed locations during spring 2014. Relative to all 60 wetlands and lakes surveyed in the IRV, use-day density at Merwin Preserve ranked 1st for all diving ducks and ring-necked ducks, 2nd for canvasback, and 11th for lesser scaup, which are all greater than annual mean rankings.

Discussion

As the disturbance intensity varied immensely between Merwin and Emiquon Preserves, so did the response of waterbird communities and vegetation communities and other cover types. Generally, changes were lesser at Emiquon Preserve and more dramatic at Merwin Preserve. At Merwin Preserve, high and variable water levels eliminated aquatic bed cover, which is uncommon in the IRV due to dynamic river levels during the growing season and high turbidity (Bellrose et al. 1983, Stafford et al. 2010). The partial connection with the Illinois River not only facilitated high water levels during spring and early summer, but also a near-complete drawdown during late summer which exposed mudflats and encouraged growth of moist-soil vegetation. Mudflats provide important foraging habitats for shorebirds during their autumn migrations through the IRV (Smith et al. 2012). Notably, piscivorous bird use days increased during autumn 2013 following the flood, likely due to the increase in fish from the Illinois River (VanMiddlesworth and Casper 2015). Although the levee breach prevented extensive accumulation of water inside Merwin Preserve and flooding of moist-soil vegetation for migrating waterbirds during autumn 2013, flooding during the subsequent spring made moist-soil vegetation and propagules available as forage.

Relatively high waterbird use of Merwin Preserve during spring 2014 was disproportionately influenced by our first aerial survey of the season, following ice-out. Increasing water levels in the Illinois River inundated Merwin Preserve through the levee breach resulting in ice-free conditions during the first aerial survey on March 17, 2014. At this time, Merwin Preserve was ice free, due to the river connection, compared to an average of 36.3% ice cover on other sites surveyed within the IRV. Lesser scaup and ring-necked ducks consume moist-soil seeds during spring migration and may have been attracted to the newly flooded moist-soil vegetation along with the open water conditions. We noted that during the second aerial survey on April 9th, 2014, few diving ducks continued to use Merwin Preserve compared to other locations which were then ice-free and may have contained more forage. Interestingly, the timing of increasing water levels in the Illinois River, relatively late ice-off in many isolated lakes and wetlands, and the open connection at Merwin Preserve allowed waterbirds access to moist-soil plants produced as a result of the 2013 flood and levee failure. Consequently, partial river connections, like those at Merwin Preserve, may benefit spring-migrating waterbirds if high water levels occur during early spring to inundate moist-soil vegetation produced during late summer and early autumn.

To simulate conditions currently existing at Merwin Preserve following the 2013 flood and levee breach, we examined river gauge data from the Army Corps of Engineers (Meredosia gauge) collected nearby Merwin Preserve during 1980–2014. During March, coinciding with peak spring waterfowl migration through Illinois (Havera 1999), river levels would have been sufficient to likely inundate >50% of Merwin Preserve (>428 ft MSL) in 27 of 35 years (77%) and provide shallow-water habitat preferred by waterbirds. During August and September of the same years, river levels would have inundated

significant portions of the Preserve in 13 of 35 years (37%) and likely prevented growth of or killed existing herbaceous vegetation prior to autumn waterfowl migration. When we examined successive years to determine the likelihood that moist-soil habitat would be produced by a late summer drawdown and subsequently flooded for spring-migrating waterfowl under historic river levels, we found conditions suitable in only in 15 of 35 years (43%).

While the partial river connection may benefit fish and some taxa of waterbirds, current conditions at Merwin Preserve would likely have resulted in habitat for fall and spring-migrating waterfowl in <50% of the last 35 years. Water levels in the Illinois River typically remain below flood stage during late summer and autumn, allowing drawdowns of shallow and backwater lakes, but late drawdowns, such as those occurring in late July, without additional management practices may produce less biomass of seeds and tubers for waterfowl (Bowyer et al. 2005, Stafford et al. 2011). If we restricted our simulation to include a drawdown occurring before July 1, the water levels in the Illinois River would be conducive in only 11 of 35 years (31%) and inundation during the subsequent spring would occur in only 8 of 35 years (23%). Spring precipitation and subsequent flooding inundate non-flooded vegetation produced during late summer and early autumn and benefit spring-migrating waterbirds, especially diving ducks which may be limited by spring habitat conditions (Anteau and Afton 2008). However, conditions at Merwin Preserve and perhaps other locations with partial connectivity to the Illinois River will fail more often than not to produce quality habitat for fall- or spring-migrating waterfowl without additional active habitat management or water control.

Relatively few changes were readily apparent in direct relation to the flood at Emiquon Preserve during autumn 2013. The proportional and actual coverage of aquatic bed vegetation increased in 2013 following a 0.85-m increase in water levels from early autumn 2012 (Hine et al. 2015). During the 6 days when water overtopped levees at Emiquon Preserve, water levels increased approximately 0.3 m and from mid-April to Mid-May surrounding the flood, water levels increased approximately 0.6 m. Thus, the change in water levels from 2012 to 2013 was only partially due to the input of flood water via surface connection. However, the relatively small annual increase in water levels greatly reduced cover of mudflats and non-persistent emergent vegetation. These changes to habitat were evident in the waterbird community response with declines in dabbling ducks, non-mallard dabbling ducks, and granivores and an increase in herbivore use-day density. Piscivore use days also declined substantially in 2013 to their lowest recorded density since 2008, and the decline is possibly related to the reduction in open water cover and expansion of aquatic bed limiting areas available for foraging. Overall, waterbird use of Emiquon Preserve during autumn 2013 was similar to the long-term average and use in 2012, indicating no significant and deleterious short-term effects of the input of floodwaters to the overall vegetation communities or waterbird use in autumn 2013. During spring 2014 at Emiquon Preserve, there were notable decreases in use days of most foraging guilds from spring 2013 and the long-term averages, although herbivorous waterbirds showed substantial increases in spring similar to autumn. Little moist-soil vegetation inside Emiquon during spring 2014 may have limited food for granivorous dabbling and diving ducks.

Clearly, tradeoffs exist in establishing hydrologic connectivity between restored floodplain wetlands and the Illinois River. If river levels are low during mid to late summer and facilitate a drawdown, mudflats will become available for migrating shorebirds and moist-soil vegetation may be produced. Although it is unlikely that autumn or early winter floods will inundate moist-soil vegetation, increased river levels following ice-out during late winter or early spring can flood vegetation and benefit spring-migrating waterbirds. However, the hydrologic variation associated with an open or partial river connection during the growing season typically precludes growth of submersed aquatic, floating-leaf aquatic, and persistent emergent vegetation which benefit herbivorous waterbirds, fishes, and summer-

nesting waterbirds. Interestingly, relatively small input of floodwaters at Emiquon Preserve inundated potential moist-soil and mudflat habitats, but did not negatively affect aquatic bed and persistent emergent vegetation communities. In restored floodplain wetlands with extensive cover of aquatic macrophytes, relatively small inputs of water early in the growing season may not have direct deleterious effects on vegetation cover; however, increasing water levels during the growing season may shift cover types away from mudflats and moist-soil vegetation and towards aquatic bed. We were unable to evaluate a restored floodplain with a managed hydrologic connection to the Illinois River during this project, but we suggest future evaluation of a managed connection allowing water inputs and outflow to facilitate drawdowns and subsequent re-flooding without exposing vegetation communities to frequent hydrological variations.

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Figure 1. Locations in the Illinois and central Mississippi River valleys aerially inventoried for waterfowl by the Illinois Natural History Survey during autumn 2013. Merwin Preserve is identified at Spunky Bottoms.

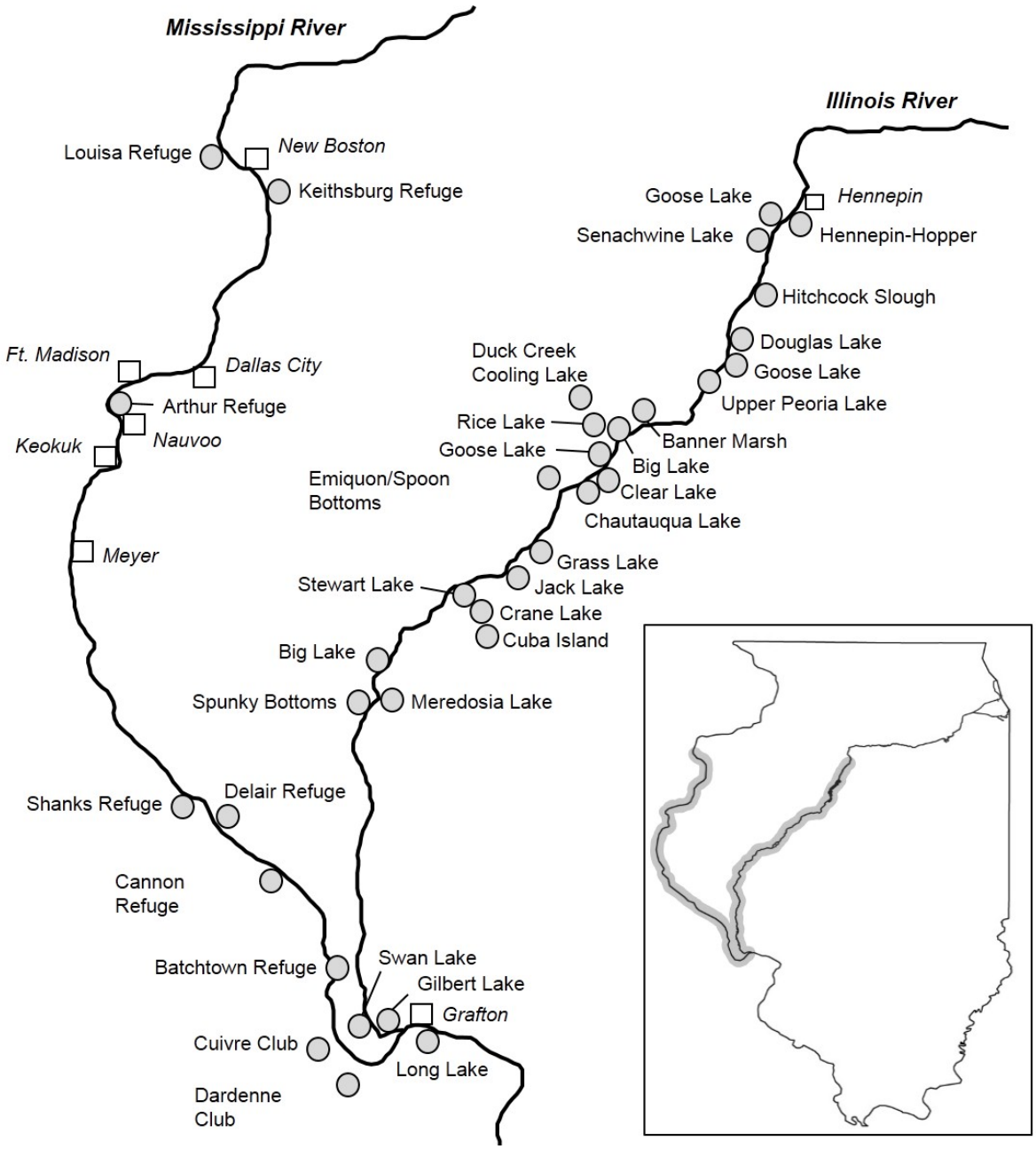

Figure 2. Locations in the Illinois and central Mississippi River valleys aerially inventoried for diving ducks by the Illinois Natural History Survey during spring 2014. Merwin Preserve is identified at Spunky Bottoms.

Table 1. Common and scientific names of waterbirds included in analyses and assigned guild based on primary foraging method and prey type.

Common Name	Species Name	Dabbling Duck	Diving Duck	Granivore	Herbivore	Piscivore
American Black Duck	*Anas rubripes*	x		x		
American Green-winged Teal	*Anas crecca*	x		x		
American White Pelican	*Pelecanus erythrorhynchos*					x
American Wigeon	*Anas americana*	x			x	
Blue-winged Teal	*Anas discors*	x		x		
Bufflehead	*Bucephala albeola*		x			
Canvasback	*Aythya valisineria*		x		x	
Common Goldeneye	*Bucephala clangula*		x			
Common Merganser	*Mergus mergini*		x			x
Double-crested Cormorant	*Phalacrocorax auritus*					x
Gadwall	*Anas strepera*	x			x	
Hooded Merganser	*Lophodytes cucullatus*		x			x
Lesser Scaup	*Aythya affinis*		x			
Mallard	*Anas platyrhynchos*	x		x		
Mute Swan	*Cygnus olor*				x	
Northern Pintail	*Anas acuta*	x		x		
Northern Shoveler	*Anas clypeata*	x				
Red-breasted Merganser	*Mergus serrator*		x			x
Redhead	*Aythya americana*		x		x	
Ring-necked Duck	*Aythya collaris*		x	x		
Ruddy Duck	*Oxyura jamaicensis*		x			
Trumpeter Swan	*Cygnus buccinator*				x	
Tundra Swan	*Cygnus columbianus*				x	
Wood Duck	*Aix sponsa*	x		x		

Table 2. Proportion of vegetation communities and other cover types at Emiquon Preserve during autumn 2007–2013 (Hine et al. 2015).

Year	Year						
	2007	2008	2009	2010	2011	2012	2013
Aquatic Bed	1.2%	22.4%	65.8%	52.5%	59.1%	47.6%	56.2%
Hemi-marsh	11.7%	20.5%	16.1%	6.1%	6.0%	4.5%	7.0%
Mudflat	1.4%	0.0%	0.0%	4.2%	0.6%	5.2%	0.0%
Non-persistent Emergent	19.9%	11.8%	1.3%	11.0%	3.4%	9.8%	5.2%
Open Water	49.1%	27.0%	12.9%	13.3%	18.4%	17.2%	15.9%
Persistent Emergent	2.9%	0.0%	0.3%	10.1%	12.3%	15.5%	15.1%
Scrub-shrub & Forested	2.7%	0.2%	0.1%	0.1%	0.2%	0.2%	0.6%
Total Wetland Area (ha)	254.7	1077.2	1803.9	1974.1	1820.6	1782.3	1943.6

Table 3. Proportion of vegetation communities and other cover types at Merwin Preserve during autumn 2007–2013.

Cover Type	Year						
	2007	2008	2009	2010	2011	2012	2013
Aquatic Bed	9.8%	13.6%	16.3%	18.2%	13.7%	13.8%	0.0%
Hemimarsh	0.0%	1.7%	0.2%	0.0%	0.0%	0.0%	0.0%
Mudflat	4.6%	0.0%	0.0%	0.0%	1.4%	11.1%	6.6%
Non-persistent Emergent	70.1%	65.7%	63.9%	53.3%	49.5%	47.4%	65.9%
Open Water	3.4%	4.4%	4.8%	13.1%	25.4%	14.9%	13.7%
Persistent Emergent	0.0%	0.7%	0.7%	0.0%	0.0%	0.0%	0.0%
Scrub-shrub & Forested	12.1%	13.8%	14.2%	15.4%	10.0%	12.6%	13.7%
Total Wetland Area (ha)	363.5	374.6	382.3	383.7	381.2	380.8	403.4

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